

THE IMPACT OF INDUCED STRESS UPON MULTIPLE-OBJECT TRACKING: RESEARCH IN SUPPORT OF THE COGNITIVE READINESS INITIATIVE

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ABSTRACT

The ability to filter distracting information and selectively attend to relevant information is critical to effective performance on the battlefield. In addition to the cognitive processing burden imposed upon soldiers, the effects of stress upon soldier cognition and action must also be accounted for in evaluating individual warfighting capabilities. The current study examines the relationship between stress and cognition by measuring performance on a multiple-object tracking (MOT) task after exposure to stress-inducing photographs. Post-exposure performance revealed significant decrements in MOT accuracy relative to pre-exposure measures and to a non-stressed control group. The stressed group also revealed greater scores on the anxiety, depression, hostility, dysphoria, and sensation seeking scales of the Multiple Affect Adjective Checklist-Revised (MAACL-R) relative to controls, indicating that the stimuli effectively stressed this subset of participants. The impact of stress on attentional selection has implications for warfighting effectiveness, especially in urban settings where non-combatants are interspersed with enemy targets.

1. INTRODUCTION

The benefits of advanced technological sophistication are frequently offset by human performance limitations. In today's "digital battlefield" the dismounted infantryman faces increasing demands on selective processing of visual information. For instance, helmet-mounted displays (HMDs) require the warfighter to process a host of visually presented information such as graphical data, digital maps, troop locations, intelligence information, and imagery from Thermal Weapon Sights and from video cameras. Given the spatially constrained size of the area in which information is displayed, much of the information must be presented in very close or overlapping spatial proximity. Consequently, the ability to filter out distracting information and selectively attend to important information becomes central to effective performance when using HMDs.

The role of selective attention is to isolate behaviorally relevant information from the multitude of sensory information impinging upon the visual system at any given time. Without such a mechanism, we run the risk of potential sensory overload. Attentional selection is accomplished via both excitatory and inhibitory processes, resulting in the enhancement of behaviorally relevant information and the suppression of irrelevant information. It has long been established that stress can alter these attentional processes.

Intuitively, one might assume that stress could only have an adverse effect on attention and performance. Indeed, seminal studies have repeatedly shown that stress narrows the capacity of attention (Callaway, 1959; Callaway & Dembo, 1958; Callaway & Thompson, 1953; Venables, 1964). Conversely, recent research has shown reduced attentional inhibition, or a broadening of attention, after induced stress (McEwen & Sapolsky, 1995; Skosnik, Chatterton, Swisher & Park, 2000).

While a substantial amount of literature supports the negative effects of increased stress on memory formation and retrieval, McEwen and Sapolsky (1995) found enhanced memory processing as a result of reduced attentional inhibition induced by mild stress. They theorized that the broadening of attention possibly aided memory by allowing for additional environmental cues that might otherwise have been suppressed. Accordingly, the effect of mild stress on attentional processing warrants further investigation.

A review of the literature on stress related research produces an overwhelming amount of information that cuts across a broad spectrum of stress-related concerns. Much of the literature examines the effects of stress on performance in the workplace or classroom and its effect on learning and memory. Equally plentiful are studies aimed at the effects of chronic stress on health and behavior, as well as the effects of post-traumatic stress on lifestyle and coping strategies. Studies designed to examine the physiological consequences of psychological stress are often aimed at addressing the influence of stress on endocrine function and the immune system, while pharmacological studies have examined the effects of stress-induced glucocorticoids and

Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE 00 DEC 2004		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE The Impact Of Induced Stress Upon Multiple-Object Tracking: Research In Support Of The Cognitive Readiness Initiative				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Laboratory Human Research & Engineering Directorate Aberdeen Proving Ground, MD 21005-5425				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES See also ADM001736, Proceedings for the Army Science Conference (24th) Held on 29 November - 2 December 2005 in Orlando, Florida., The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 5	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

epinephrine on memory and mood. In short, the scope and breadth of research examining the effects of physiologically and psychologically induced stress on health, performance, and behavior is both wide-ranging and deep. However, there appears to be a paucity of studies that examine the specific effects of stress on attentional processes and perception. While many studies have shown the effects of stress on cortisol and norepinephrine levels or on changes in cognitive performance after stress, little effort has been made to systematically examine the relationship between stress responses and cognitive measures of attention within a single study.

The current laboratory experiment is the first in a series of studies designed to systematically examine the specific effects of stress on attentional processing. Two conditions will be employed. In the experimental condition, participants passively viewed standardized photos, which have been shown to increase levels of physiological arousal and elicit a stress response. The photographs were selected from the International Affective Picture System (IAPS), a set of normative stimuli designed for use in experiments examining emotion and attention (Lang, Bradley & Cuthbert, 1997). Participants in the control condition viewed low-arousal IAPS photographs designed not to elicit a stress response. The photographs utilized in the current study were rated in accordance with Lang's Self-Assessment Manikin (SAM) affect rating system (1980). The Multiple Object Tracking (MOT) task was used to measure attentional performance across three levels of difficulty.

In MOT tasks, participants are asked to track multiple objects that move randomly among distractor stimuli. Target and distractor stimuli are visually identical, save for a pre-trial indicator that distinguishes the stimuli from one another prior to onset of movement (e.g., targets "flash" briefly while distractors remain unchanged). Targets and distractors move in a smooth yet arbitrary fashion, frequently passing one another and changing direction within the presentation window. Multiple-object tracking is hence a challenging task, necessitating the engagement of attentional processing to improve the likelihood of success.

If psychophysiological stress can improve attentional capacity, then relative to both the experimental group baseline performance and controls, participants exposed to stress-inducing photos should show improved accuracy in tracking multiple objects in the MOT task across levels of difficulty. The results will have implications for the design application of dismounted warfighter scenarios. In addition, the effect of induced stress on cognitive readiness, as defined by a heightened state of mental acuity necessary for the warfighter to accomplish the mission while maintaining

situational awareness of the operational environment, can be examined.

2. METHODOLOGY

2.1 Participants

Thirty-eight volunteers were solicited from the employee population of the U.S. Army Research Laboratory at Aberdeen Proving Ground, Maryland and from the 1/17 infantry battalion stationed at Ft. Wainwright, Alaska. All participants were verified for normal or corrected-to-normal visual acuity via examination with a Snellen eye chart. A health screening form was also used to determine possible risk to participants. Two participants were considered at risk and excluded from participating in the experiment. The remaining 36 volunteers were divided randomly into two groups of 18 each; a stress (experimental) group and a non-stress (control) group.

2.2 Stimuli and Apparatus

The Today form of the Multiple Affect Adjective Checklist – Revised (Lubin & Zuckerman, 1999) was administered. This form consists of 5 primary subscales (Anxiety, Hostility, Depression, Positive Affect, and Sensation Seeking) derived from a one page list of 132 adjectives. Participants are instructed to check all words describing how they "feel right now", or "have felt since they last completed this form." A sixth subscale, Dysphoria, is an overall distress score and is calculated from the Anxiety, Depression, and Hostility scores. Because of its improved discriminant validity and control of checking the response set, the MAACL-R Today form has been found to be particularly suitable for investigations which postulate changes in specific affects in response to stressful situations.

To serve as a stressor, participants in the experimental group were shown a set of standardized IAPS photos¹ rated as high-arousal/negative-valence in accordance with Lang's SAM affect rating system (1980). The photos in this set have been shown to evoke both physiological arousal and emotional response (Lang, Bradley, & Cuthbert, 1997). Participants in the control

¹ To assure that the high-arousal/negative-valence IAPS elicited the expected stress response relative to the low-arousal/neutral-valence photos, a group of pilot participants were exposed to a set of 24 photos and salivary amylase was measured (Chatterton, Vogelsong, Lu, Ellman & Hudgens, 1996). Those viewing the disturbing photos showed a moderate increase in stress levels.

group were shown a set of standardized photos rated as low-arousal/neutral-valence in accordance with Lang's SAM rating system. That is, these photos are associated with neither pleasant nor unpleasant material.

2.3 Design and Procedure

A MOT task was employed at three levels of difficulty to test the effects of induced stress upon attention directed at moving targets. For this task, we employed target and distractor stimuli that were visually identical, consisting of white circles on a black background. The only distinguishing factor was a brief flash prior to the onset of a trial that temporarily illuminated the targets in order to distinguish them from distractor objects. The target objects were randomly positioned among the distractors, and upon trial onset both targets and distractors began to move randomly at constant speed (Figure 1). Participants were required to track the target objects for the duration of the trial. Upon completion of the trial, movement of targets and distractors cease and participants are asked to indicate the target objects by clicking on each target item. Performance on the MOT task was determined by recording participant accuracy in correctly indicating target objects from among distractors upon termination of a trial.

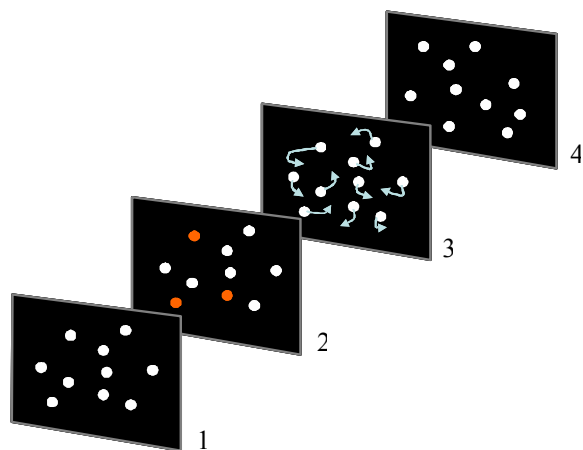


Figure 1. In frame 2, the target stimuli are identified by a temporary luminance change. The targets then return to the same color as the distractors and all stimuli begin to move independently. When the movement stops, participants must identify the new location of those items they were tracking.

Upon arrival, participants were asked to read a Volunteer Agreement Affidavit and were reminded that they could refuse or withdraw from the study at any time without penalty. In addition, volunteers completed a brief health screening form. Although the set of physiologically arousing IAPS photographs do not produce sustained heart rate or blood pressure changes,

to err on the side of safety, if an individual answered "yes" to any of the questions on the health screening form, they were precluded from participation in the experiment.

Baseline MAACL-R measures were collected prior to informing the participant of the nature of the photos they would be viewing. That is, at the time of the baseline measures, participants did not know which set of photos they would be viewing. In administering the MAACL-R, participants were asked to check all words on the list that describe how they "feel right now." Following the baseline MAACL-R, the MOT task was demonstrated and participants completed a 1-minute practice block. Upon completion of the practice block, a preliminary (baseline) session of MOT trials was presented. Each block in the initial session consisted of 24 MOT trials, with each block lasting approximately 4 minutes. Each MOT trial block was followed by a 1-minute break. The preliminary MOT session consisted of 5 MOT trial blocks (120 trials total) and lasted approximately 25 minutes.

Upon completion of the preliminary MOT session and following a minimum 5-minute break, participants in both groups were asked to view the IAPS photographs. A series of IAPS photographs were shown for a period of 6 seconds each. Prior to viewing, participants were informed of the nature of the photos. Those in the stress group were told that they may find the photos disturbing, while those in the non-stress group were simply asked to view the photos. Following exposure to the IAPS, the MAACL-R was again administered, followed immediately by another 4-minute MOT session, a second IAPS viewing, a 4-minute MOT session, a third IAPS viewing, the MAACL-R, and a 4-minute MOT session. At this time the participants were given a 5 to 10 minute break after which, the following sequence was presented: IAPS viewing, 4-minute MOT session, IAPS viewing, MAACL-R, 4-minute MOT session.

2.4 Data Analysis

The MOT accuracy data were submitted to a mixed factors ANOVA with difficulty level (4, 5, or 6 tracked items) and IAPS exposure (pre, post 1, post 2, post 3, post 4) as within-subjects factors, and group (stressed vs. non-stressed) as the between-subjects factor.

A 2 (control vs. stressed group) x 5 (IAPS exposures) multivariate analysis of variance (MANOVA) was also conducted to verify whether photographic stimuli intended to elicit increased stress were psychologically substantiated by the six subscales of the MAACL-R.

3. RESULTS

The principal measure of performance was mean accuracy in identifying the tracked items. Results of a mixed-model ANOVA revealed significant, within-subject main effects of IAPS viewing (pre, post) [$F(1, 286) = 24.3, p < .001$], difficulty level (4,5,6 targets) [$F(2, 572) = 297.7, p < .001$], and sequential trial block (1,2,3,4,5) [$F(4,1144) = 3.3, p < .05$] as well as a significant between-subject main effect of group (stress, non-stressed) following IAPS exposure [$F(1, 286) = 11.2, p < .01$]. Additionally, two-way interactions were found between group and IAPS viewing [$F(1, 286) = 4.7, p < .05$] and between trial block and IAPS viewing [$F(4, 1144) = 3.4, p < .01$]. Finally, a three-way interaction of trial block, difficulty level and IAPS viewing was found [$F(8, 2288) = 2.3, p < .05$].

There was no significant disparity in tracking accuracy between the stressed and non-stressed groups for baseline trials presented prior to IAPS photo exposure [$F(1,286) = .09, n.s.$]. However, significant differences in tracking accuracy were found between groups after exposure to IAPS photographs, with diminished performance for participants in the stressed condition over those who viewed neutral valence photos (Figure 2). Overall, performance was best when tracking 4 targets and worst when tracking 6 targets. Moreover, prior to IAPS viewing, there was a practice effect for both groups. That is, performance improved after the initial trial block, but did not differ significantly thereafter.

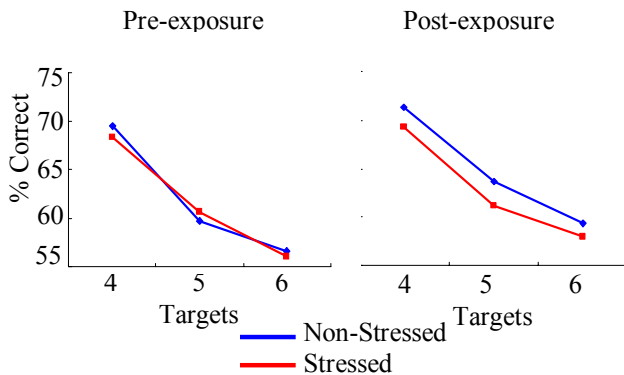


Figure 2. Prior to IAPS viewing, both groups were equally accurate in identifying the tracked items. After exposure to negative-valence photos, the stress group revealed degraded performance.

The MAACL-R indicated significant differences in the stress perception of negative affect, hostility, anxiety, and depression between those viewing the negative-valence photos and those viewing the neutral-valence photos. Specifically, the negative-valence photos resulted in higher levels of each of the negative affect subscales and consequently, lower positive affect. That

is, there was a significant main effect of IAPS viewing [$F(3,102) = 3.45, p < .05$] as well as a significant interaction between group and IAPS viewing [$F(3,102) = 5.83, p < .001$]. The results are displayed graphically in Figure 3.

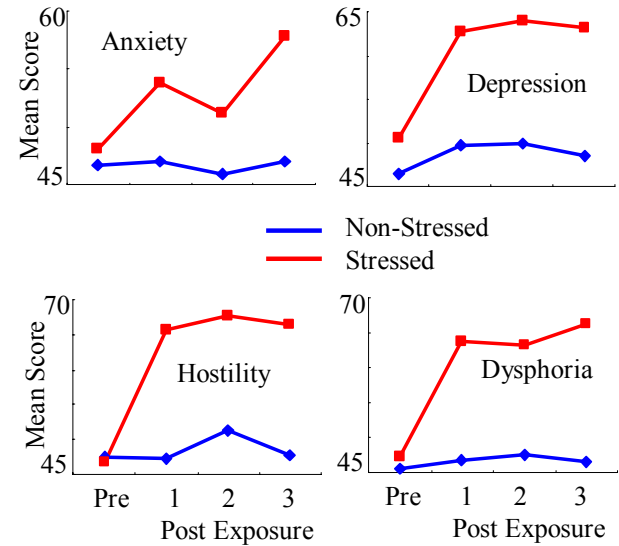


Figure 3. Prior to IAPS viewing, there was no difference in stress perception between groups; however, after viewing the negative-valence IAPS photos, the experimental group revealed elevated levels of anxiety, depression, hostility and dysphoria.

CONCLUSIONS

The MOT task addresses two critical components of cognitive readiness within a single paradigm: the cognitive complexity of tracking multiple, independently moving targets from among distractors, and the cognitive vigilance required to sustain such tracking over the temporal progression of the MOT trial. This allows for an examination of the effects of stress on cognition based upon a single task whose main characteristics, tracking and subsequent identification of moving targets among non-targets, are relevant elements of many military missions. That is, the impact of stress upon tracking multiple targets interspersed amid irrelevant objects has implications for the effect of battlefield stressors and cognitive load on warfighter effectiveness, especially in military operations on urban terrain (MOUT) where interaction with non-combatants complicates the mission objective.

While some research has shown an enhancement in cognitive performance under conditions of induced stress, in the present study, perceived stress resulted in a degradation in performance on the multiple object tracking task. Moreover, as the level of tracking

difficulty increased, the effect became more pronounced indicating that perceived stress, as a result of viewing disturbing photographs, produced a cognitive decrement.

Skosnik, et al. (2000) attribute their results of less negative priming to an attentional broadening resulting from induced stress. However, the nature of their task was very different from the present MOT task. If an attentional broadening did occur as a result of viewing the negative-valence photos, the end result may have been that individuals were unable to filter out the distractors. Consequently, performance on the MOT task would be degraded as a result of perceived stress.

The heightened state of mental acuity necessary for the warfighter to successfully negotiate the battlefield, maintain situational awareness of the operational environment, and focus upon completing mission objectives, becomes more critical as the complexity of the battle scenario increases. The basic finding presented in the current study warrants future research into the impact of combat stress upon attentionally demanding battlefield tasks, such as target discrimination, marksmanship, and reconnaissance, especially in urban settings where potential for non-combatant interference is elevated.

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